

BACKGROUND OF THE INVENTION

The present invention relates to a mechanical part that includes at least one circuit for intended to containing a fluid, and to a method for producing such a [[said]] part.

The present invention is applicable to [[in]] a broad very ~~wide~~ range of fields such as, for example, [[in]] mechanical engineering (for example, for the manufacture of cylinder heads), [[in]] printing (for the production of ink-marking [[ink]] circuits), or other ~~fields~~.

~~—The~~ fields. In addition, the present invention ~~applies~~ preferably, but not exclusively, applies to the field of plastics processing, and more particularly, to the problems posed by the thermal regulation of molding tools (dies or punches).

The thermal regulation of an injection molding tool has the function of extracting[[,]] ~~to the outside of the tool,~~ the thermal energy provided by the molten thermoplastic to the outside of the tool. Such [[This]] energy is imparted ~~had been given~~ to the thermoplastic by the plasticating screw [[so as]] to allow [[make]] the thermoplastic [[able]] to conform to the impression being made. Such [[This]] energy must then [[now]] be removed from the thermoplastic so [[that]] the part can be

ejected (without any "distortion" of the molding impression).  
Such ~~[[This]]~~ extraction takes place under conditions defined  
beforehand, during the design of the part and of the tool.

The solution most commonly used ~~to carry in the prior art~~  
~~for carrying out~~ the function of cooling and regulating molding  
tools is to produce ~~consists in producing, in the body of the~~  
~~tool,~~ a series of channels in the body of the tool, through which  
a heat-transfer fluid can circulate. ~~The circulates,~~ the nature  
of the fluid depends ~~depending~~ on the desired average temperature  
in the tool.

To obtain optimally ~~ideally~~ effective regulating channels,  
it is necessary for the channels to be able to form a layer  
facing the part, or which exactly follow the ~~following its~~ shape  
of the part, and for such channels ~~[[them]]~~ to be separated from  
the ~~[[this]]~~ part by as thin a wall as possible. In practice  
~~Of course,~~ this solution could not ~~cannot~~ be achieved, both for  
technical reasons and because of the high mechanical stresses  
generated by the injection molding process.

A similar solution is sometimes obtained by a system of  
channels having a ~~[[of]]~~ square cross section, and that  
approximately follow the shape of the part. This solution  
is used in special cases and ~~[[it]]~~ is known to be used only  
on simple geometrical shapes (mainly on cylindrical punches).\_\_

Such a solution [[,]] ~~and it~~ gives rise to the problem of sealing between the attached parts, resulting in substantial delays and manufacturing costs.

Such ~~Production of these~~ channels are most often produced by drilling, which is the ~~solution most often used~~ ~~this is the~~ least effective but [[the]] simplest solution. Since the holes can be drilled only in a straight line, an entire [[whole]] series of drilling operations is necessary in order to follow the impression as closely as possible. The circuit is then formed by using ~~the use of~~ fluid-tight plugs, or even by using ~~the use of~~ external bridging arrangements for [[the]] difficult cases, which ~~but these~~ are best [[to be]] avoided to the extent ~~as far as~~ possible due [[owing]] to the risk that the resulting circuits can be ~~of their being~~ crushed or broken while the mold is being handled.

Insufficient cooling can [[may]] result either due to [[in]] geometrical precision problems or [[in]] excessively long cycle times. In the worst cases, this can ~~it may be the~~ cause [[of]] production shutdowns, during which the mold is left open [[so as]] to be regulated by natural ~~convection.~~ Despite convection.

Despite all of these risks of malfunction, this aspect ~~function~~ of the tool is [[still]] often neglected when designing molds for injection molding. The regulating system is very often designed as the last item, and must be placed between the various

ejectors, the guiding column, etc. This has been found to be ~~[[is]]~~ erroneous because ~~[[since]]~~ this function is the keystone of the injection molding process. The ~~[[,]]~~ ~~as the~~ conditions for cooling the part play an essential role in the level of internal stresses in the injection-molded parts and in the crystallinity of the polymer, and therefore, in the ~~[[its]]~~ aging stability and the ~~[[its]]~~ mechanical ~~properties.~~

~~Consequently, the properties of the parts. Consequently,~~ production of the cooling/regulating channels currently represents a major challenge in ~~research on~~ improving performance in plastics processing.

One solution which has been proposed is disclosed in an article in the journal "*Emballages Magazine*" entitled "How to Optimize the Molding of Plastics" (January-February 2002, supplement No. 605). The disclosed ~~"How to optimize the molding of plastics")~~.

~~This~~ solution entails the production of a first, prototype mold, ~~the and then its behavior of which during cooling~~ is observed and recorded during cooling. A computer then analyzes the data and deduces ~~therefrom~~ the dimensions and the positions of pins intended to improve ~~[[the]]~~ heat exchange. This method leads to the construction of a second mold which ~~[[that]]~~ is more effective than the first mold, and which includes a set of pins

placed in accordance with ~~according to~~ a design established by the ~~computer.~~

~~—This computer.~~ Such a solution is time-consuming and requires prior experimentation.

Another solution which has been [[,]] proposed is disclosed in International Publication No. ~~patent application~~ WO 02/22341. The disclosed solution places a tubular insert provided with radially disposed pins inside a parison, consists, in order to increase the heat exchange [[,]] ~~in placing, inside a parison,~~ ~~a tubular insert provided with radially disposed pins.~~ The application of this solution is limited, and complicated to implement.

The object of the present invention is to alleviate the aforementioned drawbacks of the prior art and to provide ~~propose~~ ~~to an injection molding tool designer,~~ an entirely novel method for designing and manufacturing the tool and its fluid transport circuit.

#### **SUMMARY OF THE INVENTION**

In accordance with the present invention, the tool and its fluid transport circuit are designed and manufactured in a fully optimized manner, and in accordance with ~~according to~~ the

requirements of the part to be produced, using the process known by the trademark by means of the "STRATOCONCEPTION" which is disclosed in European Patent No. 0 585 502, and improvements of which are disclosed in French Patent Publications No. FR 2,789,188, FR 2,789,187, FR 2,808,896, FR 2,809,040 and in French Patent Application No. FR 02/80514, the contents of which are fully incorporated by reference as if fully set forth herein ~~[[®]] process.~~

In general, the "STRATOCONCEPTION" process relates to ~~This object is achieved by the invention, which consists of a method for~~ [[of]] producing a mechanical part based on the basis of a computer-aided design. In a ~~[[,]] of the type comprising:~~

- ~~[[ - a]] preliminary step, of breaking down the body of the part is broken down into elementary strata;~~
- ~~[[ - a]] strata. The step of manufacturing the elementary strata;~~
- ~~[[ - a]] strata are then manufactured, followed by reconstruction~~ [[step]] of reconstructing the part in its entirety by superposing and assembling the manufactured strata. [[,]]

During break-down characterized in that:

- ~~[[ - the]] procedure incorporates, during the breaking-down of the part, at least one fluid transport circuit is broken down the breaking-down, into elementary chambers in accordance with the~~ [[,]] according to a break-down

associated with that of the part. ~~The~~ ~~[[,]]~~ ~~of at~~  
~~least one~~ fluid transport circuit is designed and  
modeled beforehand, and the ~~[[said]]~~ elementary  
chambers are ~~[[being]]~~ produced in the elementary  
strata of the part during manufacture ~~the step of~~  
~~manufacturing the strata;~~

~~[[ - the]]~~ strata. The fluid transport circuit is then  
reconstructed, in its entirety, during ~~[[the]]~~  
superposition and assembly of the strata.

As an alternative, and variant.

~~[[ - the]]~~ ~~procedure also incorporates,~~ during break-down  
~~the breaking-down~~ of the part, ~~the breaking-down of an~~  
additional isolating circuit can be broken down into  
elementary isolating chambers in accordance with the  
~~according to a~~ break-down associated with that of the  
~~part;~~

~~[[ - said]]~~ part. The elementary isolating chambers are  
produced in the elementary strata of the part during  
manufacture ~~the step of manufacturing the strata;~~

~~[[ - the]]~~ strata. The isolating circuit is then  
reconstructed during ~~[[the]]~~ superposition and  
assembly of the set of strata.

Further in accordance with the present ~~[[The]]~~ invention,  
~~also relates to~~ a mechanical part is provided which is comprised

~~of the type comprising~~ a body with at least one fluid transport circuit. The fluid transport circuit is composed, for example, comprised of channels produced in the body and at a predetermined distance from a heat exchange surface. The ~~[[, the]] circuit is~~ ~~[[being]]~~ produced by the above-described methods, and ~~in that the circuit~~ is reconstructed in its entirety during assembly of the strata, based on a succession of elementary chambers that are brought into communication in a fluid-tight manner and that are provided in at least one portion of the strata ~~in question.~~ The fluid transport circuit is preferably filled with a fluid selected from the group of fluids including a heat exchange fluid, a thermal insulation fluid, a liquid or pulverulent material, and a marking fluid.

~~In some~~ ~~According to certain embodiments, and the circuit,~~ after reconstruction, the circuit forms ~~[[,]] in the body of the part,~~ a set of channels in the body of the part which are preferably parallel and which follow or copy channels following or copying a molding surface at a predetermined distance from the molding surface. In latter.

~~According to other embodiments, and the circuit,~~ after reconstruction, the circuit forms ~~[[,]] in the body of the part,~~ a layer-shaped ~~chamber.~~

~~Preferably, the~~ chamber in the body of the part. The



circuit preferably includes a means ~~for~~ connection to a regulating device.

As a further alternative ~~According to one embodiment,~~ the part can further include ~~furthermore includes~~ an additional isolating circuit, which is also reconstructed in its entirety during assembly of the strata. The additional isolating circuit is ~~[[,]]~~ based on a succession of elementary chambers that are brought into communication in a fluid-tight manner, and are provided in at least one portion of the strata.

~~Preferably, the fluid transport circuit is filled with a fluid chosen from the group: heat exchange fluid, thermal insulation fluid, liquid or pulverulent material, marking fluid.~~

~~The present application makes reference to a process called STRATOCONCEPTION (registered trademark) disclosed in patent EP 0 585 502 and to its improvements FR 2 789 188, FR 2 789 187, FR 2 808 896, FR 2 809 040 and FR 02/80514, the contents of which are fully incorporated here by way of consequence.~~

Further description of the present ~~[[The]]~~ invention is ~~will~~ be more clearly understood with the aid of the description given below, with reference to the following drawings. ~~appended figures.~~

## BRIEF DESCRIPTION OF THE DRAWINGS

- [[ - ]] ~~figure~~ Figure 1 is [[ : ]] a three-dimensional view of a mold with ~~according to the~~ prior art [[ with ]] cooling channels. [[ ; ]]
- [[ - ]] ~~figure~~ Figure 1a is [[ : ]] a vertical section of the mold of Figure 1. ~~in figure 1a,~~
- [[ - ]] ~~figures~~ Figures 2a and 2b illustrate [[ : ]] the principle of breaking down the mold of Figure ~~figure 1a~~ into unitary cells. [[ ; ]]
- [[ - ]] ~~figure~~ Figure 3 is [[ : ]] a three-dimensional view of a mold which has been stratified, in accordance ~~with according to the~~ present invention, and which includes ~~including~~ follower-axis channels for the circulation of a regulating fluid that follows the shape of the molding surface. [[ ; ]]
- [[ - ]] ~~figures~~ Figures 3a and [[ , ]] 3b are [[ : a ]] vertical sections of the [[ a ]] mold of Figure ~~figure 3,~~ and its break-down into unitary cells. [[ ; ]]
- [[ - ]] ~~figure~~ Figure 4 is [[ : ]] a three-dimensional view of a mold which has been stratified, in accordance ~~with according to the~~ present invention, and which includes ~~including~~ follower-surface channels for fluid circulation. [[ ; ]]
- [[ - ]] ~~figures~~ Figures 4a and [[ , ]] 4b are [[ : a ]]

vertical sections of the ~~[[a]]~~ mold of Figure  
figure 4, and its break-down into unitary cells.  
[[;]]

[[ - ]] figure Figure 5 is ~~[[;]]~~ a three-dimensional view  
of a mold which has been stratified, in accordance  
with ~~according to~~ the present invention, and which  
includes a follower layer for the circulation of  
a ~~[[the]]~~ regulating fluid ~~[[,]]~~ which follows or  
copies the shape of the molding surface. ~~[[;]]~~

[[ - ]] figure Figure 5a is ~~[[;]]~~ a vertical section of  
the mold of Figure figure 5. ~~[[;]]~~

[[ - ]] figure Figure 6 is ~~[[;]]~~ a nonlimiting  
representation of the ~~[[a]]~~ follower layer.  
~~according to the invention;~~

[[ - ]] figures Figures 7a and ~~[[,]]~~ 7b are ~~[[; a]]~~  
representations of two successive strata defining  
the follower layer of Figure 6. ~~the previous~~  
~~figure;~~

[[ - ]] figure Figure 8 is ~~[[;]]~~ a partial, nonlimiting  
representation of a stratum that includes fins for  
producing a laminar effect in the follower layer.  
~~[[,]] this example not being limiting;~~

[[ - ]] figure Figure 9 is ~~[[;]]~~ a partial, nonlimiting  
representation of a stratum that includes fins  
for producing a turbulent effect in the follower  
layer. ~~[[,]] this example not being limiting;~~

- [[ -]] ~~figure~~ Figure 10 is [[ :]] a representation of a unitary thermal cell of a regulating follower layer. [[ ;]]
- [[ -]] ~~figure~~ Figure 11 is [[ :]] a schematic section of a mold which has been stratified in accordance with ~~according to the~~ present invention, and which includes isolating follower channels. [[ ;]]
- [[ -]] ~~figure~~ Figure 12 is [[ :]] a schematic section of a mold which has been stratified in accordance with ~~according to the~~ present invention, and which includes an isolating follower layer. [[ ;]]
- [[ -]] ~~figure~~ Figure 13 is [[ :]] a diagram of a method of filling the isolating layer or channels. [[ ; and]]
- [[ -]] ~~figure~~ Figure 14 is [[ :]] a diagram of a dynamic regulating device in accordance with ~~according to~~ the present invention.

#### **DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS**

Figure ~~Referring firstly to figure 1~~ [[ , this]] shows the conventional [[ or]] principle of cooling a mold (1). Several regulating channels (2) are produced by drilling and/or by the use of plugs. The regulating channels (2) are [[ ,]] parallel to the molding surface (3) of the mold (1), which is shown in Figure 1a, after the molding tool has been manufactured. The regulating channels (2) are placed [[ , and]] at locations that are generally

defined empirically by the mold designer.

Figures 2a and 2b ~~[[show]]~~ schematically show the basic concept ~~[[idea]]~~ of the present invention. In accordance with the present invention, and ~~which consists, so as~~ to make it easier to space the channels and to determine their dimensions, ~~the in breaking down, into elementary cells (4), over a given thickness, that~~ region of the mold which surrounds the molding surface (3) which will be in contact with the material to be molded and which will consequently be subjected to ~~[[the]]~~ heating and cooling stresses during production of the ~~part.~~

~~More precisely, figures part, is broken down into elementary cells (4) over a given thickness. For ease of understanding, Figures 2a and 2b [[show]] schematically show such a break-down into unitary thermal cells for the conventional mold shown in Figure 1 [[,]] applied to one case of the prior art, so as to make it easier for the reader to understand the invention. The~~ ~~[[This]] break-down shown in Figures 2a and 2b is only one of the break-downs that can be employed to facilitate the determination of means for making it possible and easier to determine the dimensions of the channels.~~

In accordance with the present ~~According to the~~ inventive concept, each cell is determined so that the cell is ~~as to be~~ traversed by at most one regulating channel. The ~~[[, the]]~~

positions and the dimensions of the channels which are thereafter ~~[[being]]~~ calculated will depend thereafter, ~~depending~~ on the thermal stresses that the affected ~~[[this]]~~ region of the mold will have to undergo during the various operations for ~~[[of]]~~ producing the part (molding, blowing, cooling, demolding, etc.).

The foregoing inventive ~~[[basic]]~~ concept for ~~of the~~ ~~invention consists in~~ designing and producing optimized regulating channels is performed using the "STRATOCONCEPTION" ~~[[®]]~~ process previously referred to. The design of the ~~[[said]]~~ channels derives ~~[[stems]]~~ from prior modeling, in terms of unitary thermal cells, but this is not ~~limiting~~.

~~— A to be taken as limiting.~~ As an example, a unitary cell (22) (see Figure ~~figure~~ 10) is formed, over a given thickness, from a part of the mold (22') in contact on one of its faces with the polymer to be cooled, from a part of this polymer (33), and from a unitary chamber (15) in which the fluid circulates.

Figures 3, 3a and 3b show a first ~~embodiment of the~~ application of the foregoing basic principles to a stratified mold produced using the "STRATOCONCEPTION" ~~(registered trademark)~~ process (or [[by]] one of its improvements). In this application ~~mentioned in the introduction.~~

~~— According to this process,~~ the mold (1) is produced ~~[[by]]~~

using software that breaks the ~~[[said]]~~ mold down into elementary strata (7). The ~~[[, the]]~~ strata (7) are ~~[[then]]~~ produced by micromilling ~~[[in]]~~ a plate. The ~~[[, the]]~~ strata (7) are then ~~[[being]]~~ joined together by superposing the strata ~~[[them,]]~~ so that one of the inter-stratum planes of the stratum  $(7_i)$  is applied against one of the inter-stratum planes of the next stratum  $(7_{i+1})$ .

In accordance with ~~To apply the principle of the present invention:~~

~~[[ - each]]~~ invention, each stratum in regions of the mold ~~region~~ concerned with ~~[[in the]]~~ heat exchange is calculated ~~[[so as]]~~ to include a regulating channel (2) that emerges in one of the inter-stratum planes ~~[[,]]~~ (either the upper plane of a stratum or the lower plane of a stratum). The requirements of the part, for example, the cycle time, the characteristics of the material, etc., will dictate the dimensions of the channels (2). The ~~and~~

~~[[ - the]]~~ channels are dimensioned or designed beforehand, according to the requirements of the application, and are produced by micromilling during production ~~the step~~ of ~~producing~~ the strata. The channels (2) ~~[[,]]~~ ~~and~~ ~~these~~ are then reconstructed in their entirety upon assembly of ~~on assembling~~ the strata.

~~It is therefore the requirements of the part, for example the cycle time, the characteristics of the material, etc. that dictate the dimensions of the channels.~~

~~The~~ To make it easier to cut the channel (2) by laser or water-jet micromilling in a stratum (7) of the series (7<sub>i</sub>, with i from 1 to n), and because a cross section with a square or rectangular base improves the heat exchange compared with a circular cross section, provision is made, for the embodiment shown in Figures ~~figures~~ 3a and 3b includes ~~[[,]]~~ for there to be at least one channel (2) of square cross-section in the stratum, or in the strata (7) of the mold region in question. The channel has ~~[[, with]]~~ a plane bottom (8) parallel to the inter-stratum plane, and two side walls (9, 10) perpendicular to the inter-stratum plane (5 or 6) from ~~[[into]]~~ which the ~~[[said]]~~ channel (2) emerges. Such an ~~[[This]]~~ embodiment is referred to as a "follower axis" embodiment because ~~[[as]]~~ the longitudinal axis (11) of the channel is located at a predetermined distance (d) from the molding surface (3). Such an embodiment makes it easier to cut the channel (2) in a stratum (7) of the series (7<sub>i</sub>, with i from 1 to n), by laser or by water-jet micromilling. Providing a cross-section with a square or rectangular base also improves the heat exchange compared with a circular cross-section.

The embodiment shown in Figures ~~figures~~ 4, 4a and 4b



includes ~~provides~~ a channel (2), at least one of the side walls (13, 14) of which is shaped ~~[[so as]]~~ to reproduce or copy a portion of the molding surface (3). Such an ~~[[this]]~~ embodiment is referred to as a "follower surface" embodiment because ~~[[)],]]~~ ~~that is to say~~ all the points on the ~~[[said]]~~ follower side wall (for example, the wall (14) shown) are located at a distance (d') from the molding surface (3), with the bottom (12) and the other side wall (13) remaining parallel, or ~~[[and]]~~ optionally, perpendicular, respectively, to the inter-stratum plane (5 or 6).

For the ~~[[these]]~~ embodiments shown in Figures ~~figures~~ 3a to 4b, the channels are produced by turning the strata over and by providing the channels with ~~[[have]]~~ a depth less than the thickness of one stratum. It is to be understood that such ~~Of course, these~~ embodiments are nonlimiting examples, and that the channels can ~~[[may]]~~ have other shapes, and a depth greater than the thickness of one stratum.

The corners between the walls and the bottom of the channels are "broken" ~~so as~~ to limit stress concentrations.

~~—The concentrations.~~ The channels follow the molding surface at a predetermined depth (d') that is constant, or that varies, depending on the region to be cooled or the cooling requirements.

The position of a channel in the interface plane of a

stratum ( $7_i$ ) is calculated so that, when the strata ( $7_i$ ) are being stacked, the ~~[[said]]~~ channel is blocked by the interface plane of the next stratum ( $7_{i+1}$ ), so that ~~without there is no ever~~ ~~being an overlap between the two emerging channels.~~

~~—~~ The channels. The size and cross-section of the channels is calculated according to the amount of heat to be removed.

~~In~~ ~~According to~~ another embodiment of the present principle ~~of the invention,~~ shown in Figures ~~figures~~ 5 and 6, the mold (1) includes a fluid circulation layer (15) that follows or copies the shape of the molding ~~surface.~~

~~—~~ This surface. This follower layer has a predetermined thickness and is bounded by a surface (16) facing the molding surface (3) and a surface (17) facing toward ~~towards~~ the outside of the mold. The follower layer is predetermined so that all ~~[[the]]~~ points of the surface (16) facing the molding surface are at a predetermined distance or depth (D) from the ~~[[said]]~~ molding surface (3), which ~~[[ - this]]~~ is why this ~~[[said]]~~ circulation layer has been called a follower layer. The ~~[[This]]~~ distance (D) is constant, or can vary, depending on the region to be cooled or the thermal stresses. Such a ~~[[This]]~~ fluid layer constitutes a true, continuous thermal barrier surrounding the part to be ~~produced.~~

~~—A produced.~~ The follower layer (15) has been exemplified by a solidified fluid, which is ~~and then~~ shown in isolation in Figure figure 6, with a a ~~[[its]]~~ feed header (18) for ~~[[the]]~~ inflow of the regulating fluid and a ~~[[its]]~~ fluid outlet header (19).

As in the previous illustrative examples, the mold is produced by a "STRATOCONCEPTION" process. In ~~[[,]]~~ ~~and in~~ each stratum which is involved in the heat exchange, a portion of the circuit, which will be referred to as an ~~called the~~ "elementary chamber" (20), is produced during the micromilling step, and ~~[[then]]~~ the circuit is then formed in its entirety after all of the strata have been superposed.

The two strata ( $7_i$ ) and ( $7_{i+1}$ ) of the mold that surround or define the chamber for circulating ~~[[,]]~~ ~~in which~~ the fluid of the follower layer of Figure figure 6 ~~circulates,~~ have been shown in Figures figures 7a and 7b.

~~—This 7b.~~ Such a fluid layer constitutes a true, continuous thermal barrier surrounding the part to be ~~produced.~~

~~—The produced.~~ The corners between the faces and the bottom of the chamber are also broken, ~~[[so as]]~~ to limit stress concentrations and head losses.

~~A Furthermore, a~~ multiplicity of transverse fins (21) can  
further be ~~[[is]]~~ provided inside the chamber, for mechanical  
reinforcement between the two walls and for stirring the ~~fluid.~~

~~—The fluid.~~ The fins can ~~[[may]]~~ be of various shapes  
depending on the application ~~applications~~ and the desired  
effects, for example, a laminar effect (see Figure ~~figure~~ 8)  
or a turbulent effect (~~figure 9~~).

~~—The~~ (see Figure 9). The shape, size and cross-section of  
the fins depend on the amount of heat to be removed and on the  
requirements due, for example, to the mechanical stresses ~~[[:]]~~  
(join radius between the fins and the faces of the layer, etc.).

~~The~~ According to the invention, the follower layer (15) can  
be broken down into unitary heat exchange cells (22) for the  
purpose of mathematically modeling all of the heat exchanges  
undergone or transmitted by the mold during the production of  
a ~~part.~~

~~—A part.~~ A unitary exchange cell (22) is individually  
illustrated ~~individually~~ in Figure ~~figure~~ 10 and is shown  
diagrammatically on one of the strata ( $7_{i+1}$ ) in Figure ~~figure 7b.~~

~~—The 7b.~~ The various characteristic parameters of the  
~~[[this]]~~ virtual base cell (22) are used, in accordance with

the present invention, for mathematically calculating in ~~[[an]]~~ optimum manner the dimensions of the part and of the circuit before they are produced. This is done, using techniques which are otherwise known, by writing ~~[[,]]~~ ~~within the competence of a person skilled in the art,~~ heat balance equations using analytical models and/or multiphysical numerical simulations.

Two further ~~According to two more~~ embodiments are ~~[[,]]~~ shown in Figures ~~figures~~ 11 and 12, which operate ~~and in order~~ to limit the thermal conduction toward the sides of the mold (convective losses with the outside) and/or toward the bottom of the mold (conductive losses with the machine frame). These ~~of the mold, said molds include includes,~~ respectively, a plurality of isolating follower channels (23) (Figure ~~figure~~ 11), ~~and~~ ~~[[,]]~~ parallel to the isolating follower channels (23) ~~[[them]]~~, an isolating follower layer (24) (Figure ~~figure~~ 12). Such embodiments can also be ~~[[,]]~~ ~~these also being~~ produced during the micromilling step of the "STRATOCONCEPTION" process, and can be designed in the same way as the regulating follower channels (2) or the regulating follower layer (15).

The isolating channels (23) and the isolating layer (24) are located at a constant, or at a variable distance from the regulating follower layer (15), and are located on the outside of the follower layer (15) ~~latter, placing them that is to say~~ between the follower layer (15) and the outside of the mold (the

side and bottom ~~faces~~).

~~—The faces).~~ The dimensions and the cross-sections of the isolating channels (23) and the isolating layer (24) depend on the isolation to be provided, and are also obtained from multiphysical numerical simulations. For example, the isolating channels (23) and the isolating layer (24) ~~[[they]]~~ are thicker when they are close to the machine platens than when they are close to the external faces, since the losses by conduction into the platens are greater than the losses ~~[[those]]~~ by natural convection relative to ~~as regards~~ the external ~~faces~~.

~~—The faces.~~ The isolating channels and layers form either an active isolation, or secondary regulation, or a passive isolation if they are filled with an insulating material.

Figure 13 ~~[[shows]]~~ schematically shows a method of filling a mold with an insulating resin (25) in a vacuum chamber (26), for achieving ~~passive isolation~~.

~~—A isolation.~~ A volume of resin (25) ~~[[,]]~~ ~~which is greater by a few percent (owing to shrinkage) than the internal volume of the channels or the layer to be filled,~~ is introduced under an air vacuum into the ~~[[said]]~~ internal volume. The volume of resin (25) is greater by a few percent (owing to shrinkage) than the internal volume of the channels or the layer to be filled. A

telltale (27) is used to ensure complete filling.

Figure 14 shows an example of an active thermal regulating device for operating on the regulating fluid circulating in a follower layer (15) which is externally isolated ~~externally~~ by an isolating layer ~~(24)~~.

~~—The (24).~~ The cooling fluid (28), at a temperature ( $T_1$ ), is sent by a pump (29) into the chamber (20) of the follower layer (15). If necessary, a ~~[[A]]~~ solenoid valve (30) controlled by a regulator (31) mixes ~~[[,]] if necessary,~~ a colder liquid (32) at a temperature ( $T_2$ ) with the cooling liquid (28). Such mixing will depend ~~depending~~ on the measured difference between a temperature ( $T_3$ ) measured in the mold region lying between the molding surface (3) and a ~~[[the]]~~ reference temperature ( $T_4$ ) chosen for the regulation being performed.

Moreover, to obtain a molding tool suitable for withstanding the mechanical stresses to be encountered, a mechanical brace can be provided ~~provision is made,~~ during the bonding of the strata. This includes ~~[[,]] for there to be a mechanical brace,~~ an application of mechanical adhesive on the regions extending from the channels, as far as the outside of the mold, and an application of adhesive with a predetermined thermal conductivity on the regions extending from the cooling circuits, ~~[[and]]~~ as far as the molding surface. The term "cooling circuit" is to be

understood to mean both the network of channels and the layer construction.

In general, the method of the present invention ensures that the strata are held in place in a technically and economically suitable manner for the intended application by the choice of a technique for assembling the strata, namely, adhesive bonding, brazing, screwing or the like.

The [[A]] method of ~~according to~~ the present invention makes it possible to cause ~~make the~~ regulation of the tools to comply with the requirements of the parts to be produced, allowing very fine regulation in the case of high-performance parts, or ~~[[else]]~~ active regulation in the case of consumer parts. This serves to optimize regulation of the tools, to improve the productivity of the tools, to optimize the mechanical strength of the parts being produced, to reduce geometrical distortion, to reduce internal stresses due to cooling, to reduce the internal stresses due to filling, to reduce thermal inertia of the tools, and to reduce their weight. We thus:

- ~~[[•]] optimize the regulation of the tools;~~
- ~~[[•]] improve the productivity of the tools;~~
- ~~[[•]] optimize the mechanical strength of the parts produced;~~
- ~~[[•]] reduce their geometrical distortion;~~
- ~~[[•]] reduce their internal stresses due to cooling;~~



- [[•]] ~~reduce their internal stresses due to filling,~~
- [[•]] ~~reduce the thermal inertia of the tools; and~~
- [[•]] ~~reduce their weight.~~

Furthermore, it is possible to produce bulk or crude items (preformed or otherwise) dedicated to a part, with the optimized system of channels already ~~produced.~~

~~Each produced.~~ Each stratum is seen as an independent solid. As a consequence, [[thus]] one is concerned only with the heat ~~that is~~ supplied to the stratum [[it]], and the channel is dimensioned in this way.

Hotspots can, ~~The hotspots may~~ therefore, be treated with greater ~~care.~~

~~Any care.~~ Any imbalances in [[the]] cooling, due to the mold/material contact conditions and/or [[to]] difficulties of gaining access between the die and the punch, can [[may]] be eliminated.

At any point in the impression, heat removal is ~~optimized.~~

~~It optimized.~~ It is possible to achieve uniform cooling [[,]] (in terms of flux, temperature, heat transfer coefficient) over the entire surface of the part, while still ensuring a

cooling time which is adjusted to the shortest possible, or minimum cooling time, and while nevertheless limiting the residual stresses and ~~[[the]]~~ deformations in the part.

Due ~~Thanks~~ to the low inertia of the mold, it is possible to control the cooling dynamically. Consequently ~~[[Thus]]~~, it is possible to heat the mold, after ejection of the part, to keep the mold ~~[[it]]~~ hot until the end of the filling operation, and to then ~~[[to]]~~ cool the mold ~~[[it]]~~. Mold cooling is started slightly before the end of a filling, ~~[[this]]~~ depending on the reaction time of the tool itself (a very short time due ~~thanks~~ to the reduced inertia of such ~~tools~~).

~~By tools~~). By improving the filling operation, its duration is shortened, making it easier for the polymer to flow. The ~~[[,]]~~ ~~and the~~ level of internal stresses in the injection-molded part is also reduced.

The combination of optimized cooling with dynamic control of the thermal regulation of the mold allows the cycle time to be reduced by decreasing the filling time and the cooling ~~time~~.

~~This time~~. This combination also allows the internal stresses in the injection-molded parts to be considerably reduced, which ~~[[ - this]]~~ reduces ~~[[their]]~~ distortion and ~~[[their]]~~ post-shrinkage of the parts, and which increases the

[[their]] dimensional quality and improves the [[their]] aging behavior.

~~Irrespective behavior of the parts.~~ Irrespective of the type of cooling desired, the dimensional, structural and mechanical qualities of the injection-molded parts are improved, whether the parts are ~~these be~~ high-performance products, attractive products or consumer products.

Heat ~~The heat~~ transfer is optimized by cell modeling, charts and the simulations ~~means being~~ used to choose each regulating parameter.

~~The parameter.~~ The positioning of ~~the fins~~ and the [[their]] dimensions of the fins influence the heat transfer, the mechanical strength of the tools, and the control of turbulence (header losses, etc.). Such [[This]] positioning must, therefore, be studied and optimized using numerical simulation and optimization tools.

The design of the feed headers (18) and the outlet headers (19) is [[a]] key [[point]] for regulating fluid flow control. This design is also simulated and numerically optimized (for example, with reference to Figure 6, by providing wider or more numerous nozzles (34) at the necessary points) ~~(see figure 6)~~.

The time needed to bring the tools into service (to temperature) is shortened. The ~~Their~~ weight of such tools is also reduced.

The mold has a low thermal inertia ~~[[.]]~~ ~~This is~~ due to thermal and mechanical optimization of the wall thickness between the follower layer and the molding surface. The thermal inertia of the mold can ~~[[,]]~~ ~~and may~~ also be increased by the isolating action of the second layer, if necessary. As a result, the ~~[[The]]~~ volume to be regulated is ~~thus optimal.~~

~~— This minimal~~ optimal. Minimal inertia gives the tools a greater production capacity. This is because ~~not only is~~ the regulating time is not only optimized, but the tool returns more rapidly to its initial conditions in order to start a new cycle.

Of course, the examples and/or applications described above do not limit the scope of the present invention.

In particular, the present invention extends to many other known fields of application, namely metal foundry work, the building industry, the printing industry or ~~others.~~

~~— In point of fact, depending~~ others. Depending on ~~[[the]]~~ requirements, the fluid chosen can ~~[[may]]~~ be a liquid, a gas or a powder, and can ~~[[may]]~~ be used, for example, for ~~[[the]]~~

purposes of heat exchange, for isolation, for marking, for plugging and/or for assembly and/or rigidification by solidification (or other processes, etc.).

Moreover, and for the sake of simplification and clarity, while the above-described [[a]] break-down operations have [[has]] been performed in parallel planes, [[but]] this is in no way limiting, and such operations can [[it may]] also be performed in warped ~~surfaces~~.

~~It surfaces.~~ It should also be mentioned that break-down ~~the breaking-down~~ of the circuit or circuits is tied to that of the part, in the sense that this can [[may]] be identical, or tied by a mathematical relationship.

Finally, while the term "cell" has ~~may have~~ been used ~~in the text~~ with various qualifiers, the term [[but]] intellectually [[it]] denotes the same concept.